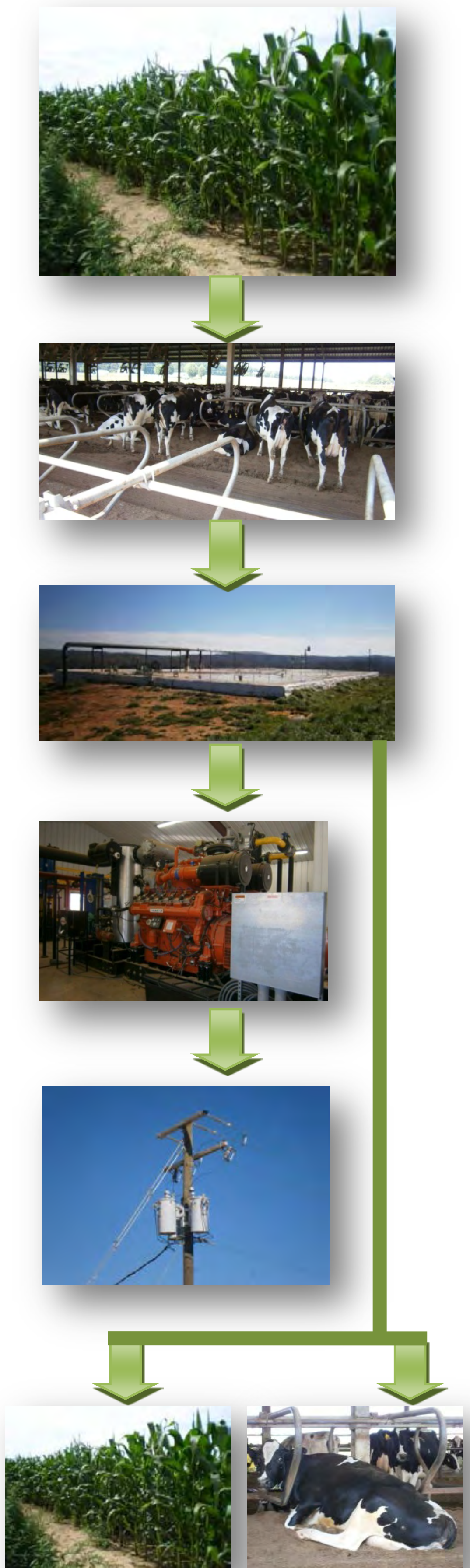


Transforming Manure to Energy:

A discussion and walking tour of DAIRY ENERGY INC.

DAIRY ENERGY INC.
269 VanDerHyde Dairy Road
Chatham, VA 24531

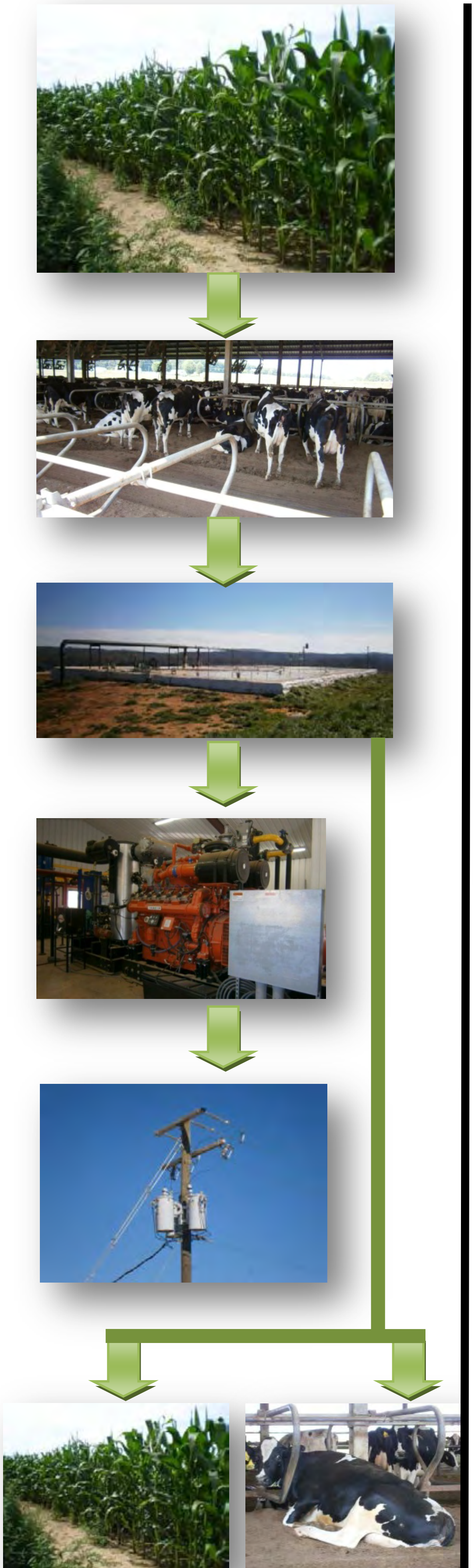
April 03, 2012

Prepared by
Jactone Arogo Ogejo and Elizabeth Collins

Biological Systems Engineering

Bioresidue Management and Utilization Program

Virginia Tech *Invent the Future*



Transforming Manure to Energy:

A discussion and walking tour of DAIRY ENERGY INC.

Tuesday, April 3, 2012
10 a.m. – 12 noon
DAIRY ENERGY INC.
269 VanDerHyde Dairy Road
Chatham, VA 24531

Welcome and Introductions ....Martha A. Walker, Ph.D.
Community Viability Specialist, Virginia Cooperative Extension

Greetings and Overview of DAIRY ENERGY, INC.
Roy VanDerHyde and Kathleen VanDerHyde

Defining the Process: A walking discussion
Jactone Ogejo, Ph.D.
Associate Professor, Biological Systems Engineering
Virginia Tech

The walking tour is offered through the partnership of multiple organizations and agencies including:

- United States Department of Agriculture Rural Development
- United States Department of Energy
- Virginia Department of Mines, Minerals and Energy, Division of Energy
- Virginia Department of Agriculture and Consumer Services
- Virginia Farm Bureau
- Virginia Foundation for Agriculture, Innovation and Rural Sustainability (Virginia FAIRS)
- Pittsylvania County Office of Agricultural Development
- Virginia Tech
- Virginia Cooperative Extension

Funding for the DAIRY ENERGY INC. project was provided by
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USDA Rural Development
USDA Natural Resource Conservation Services
Pittsylvania County Soil & Water
Virginia Foundation for Agriculture, Innovation and Rural Sustainability

Anaerobic Digestion: Overview and Benefits

- Anaerobic digestion converts organic matter to biogas in the absence of oxygen. Manure and other organic residues like municipal waste water sludge, food processing and industrial waste, crop residues, and energy crops are rich in organic matter and can be converted to biogas. The bacteria that breakdown organic matter occur naturally in the environment, and can be harnessed for biogas production in engineered digesters.
- Biogas is a renewable gaseous fuel composed of a mixture of combustible and non combustible gases. The combustible gases include methane (CH_4) and hydrogen (H_2). The inert gases and include carbon dioxide CO_2, hydrogen sulfide (H_2S), ammonia (NH_3), water vapor (H_2O) and others depending on the feedstock. Typical biogas content: CH_4 ranges from 50 to75% and CO_2 ranges from 25 to 45% by volume.

Benefits

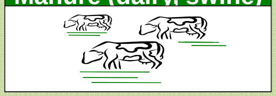
- Reduced environmental pollution/nuisance caused by odor
- Fertilizer value of manure is maintained because little or no change in the nutrients occur. The liquid is easy to pump, especially after solids separation
- Solids can be recycled as bedding, used as fertilizer, or organic matter amendment to soil
- Process reduces the chemical oxygen demand of the manure (some times called strength of manure)
- Depending on the digester temperature, pathogen inactivation may occur
- Reduces livestock related emissions of methane a greenhouse gas
- Where applicable, can provide income from renewable energy and carbon credit markets

Anaerobic Digestion Process

Feedstock

Organic materials: Contain water, minerals, and organics. Only the organic portion which contains carbohydrates, fats, lipids, and/or proteins can be converted to biogas. In general, the gas yield depend on the volatile solids content of the feedstock that can be eaten by bacteria in the time it stays in the digester.

Manure (dairy, swine)



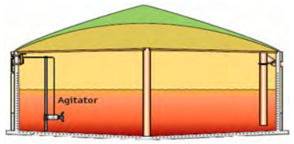
Food waste

Energy crops

Other

Digester

Numerous bacteria naturally present in the environment work together to breakdown the feedstock to produce organic acids necessary for biogas production. The bacteria can be divided into four groups based on what they do in the process of producing biogas



Digester temperature:
- Psychrophilic: 41-77°F
- Mesophilic: 86-104°F
- Thermophilic:122-144°F

Digester type examples:
- Complete mix
- Plug flow
- Mixed plug flow
- Covered lagoons
- Attached growth

Digester products

Biogas
- Electricity
- Heat
- Pipeline grade gas
- Transportation fuel
- Renewable Energy credits
- Carbon credits

Digestate

Solids
- Bedding
- Fertilizer
- Feedstock for combustion or gasification systems
- Compost: soil amendment

Liquid
- Fertilizer

Digester Feedstock

- Raw manure is generated from the milking and heifer barns. The milking barn houses about 1,200 cows.
- The manure is scraped from the barn floors every 30 minutes and gravity fed to the transfer pit. The scraped manure then flows to the reception pit and pumped to the digester.
- Wash water from the milking parlor is mixed with the scraped manure as part of the to the digester feedstock. However, the volume of wash water is very little compared to manure.
- The system has capacity to take other feedstock, but currently using manure and other organic sources from the farm.

Milking parlor wash water is fed to the digester

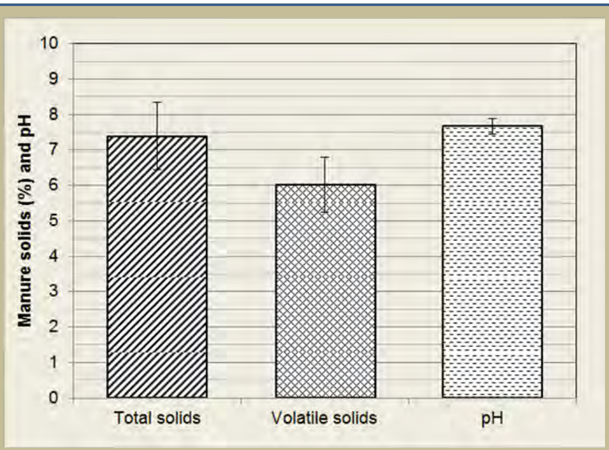
Reception Pit

- Divided into three compartments or sections. Each section has a capacity of 24,000 gallons. The pit is designed to allow overflow between adjacent sections.
- Continuously receives manure as the barns are scraped, providing temporary storage until the manure is pumped to the digester.
- About 25,000 gallons of raw manure pass through the reception pit each day.
- Equipped with agitators to mix manure and pumps to transfer manure to the digester (see Pumping Station).
- If necessary, manure flow can be redirected to bypass the reception pit and digester.

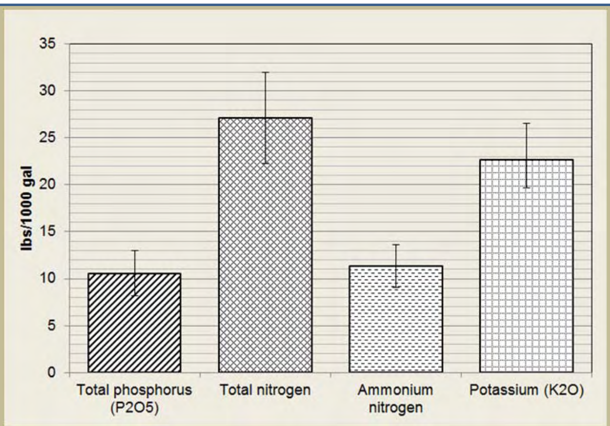
Section III: Storage for feedstock for co-digestion

Section I: Raw manure storage manure before feeding to digester

Section II: handles treated effluent from earthen pond during transfer and/or land application. The pond stores separated liquid from the digester

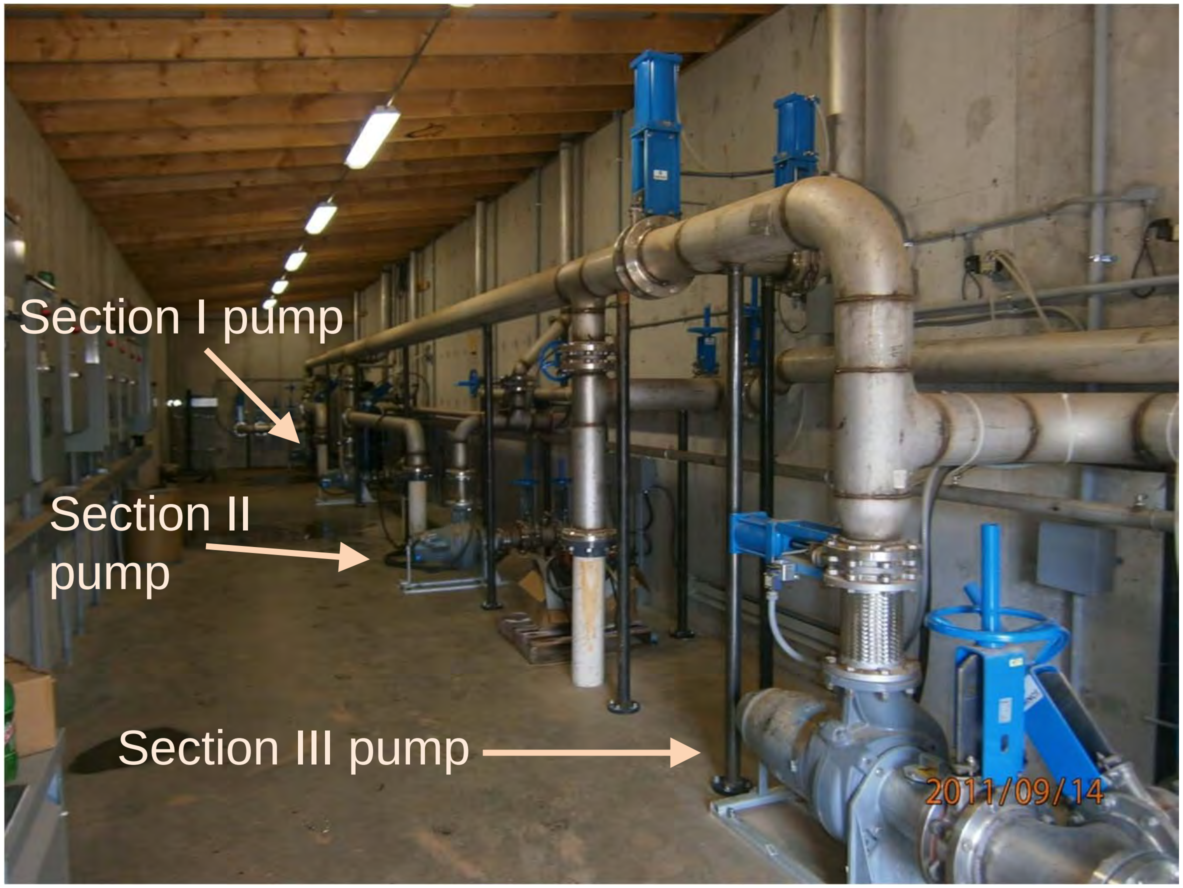


The solids content and the pH of the manure fed to the digester are very consistent. Raw manure has a total solids content of 7.4%. The average volatile solids in the raw manure accounts for about 80% of the total solids. Volatile solids can be used as an indicator of biogas yield potential. The average pH of the raw manure is about 7.7



Major nutrients in raw manure have little variability. The ratio of total nitrogen to total phosphorus is about 2.6 on a mass basis. Ammonium-N accounts for 42% of the total nitrogen and reactive P accounts for 13% of total P in raw manure.

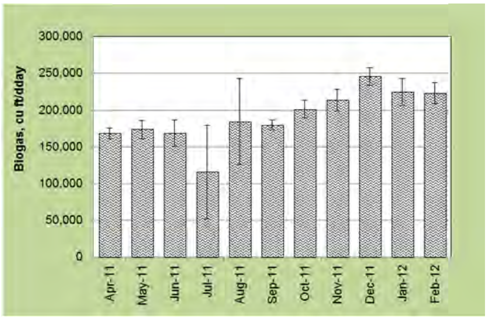
Pumping Station



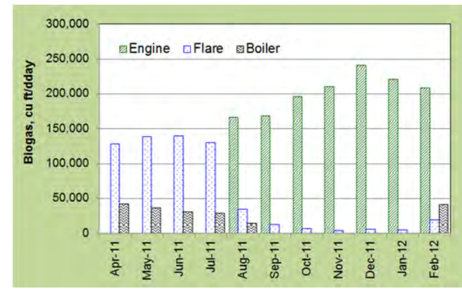
- Pump: Flygt 3127 centrifugal pumps rated at 7.5 hp; delivers 1,000 US gallons per minute at 25 ft. of head
- Section I pumps mix and transfer raw manure from the reception pit to the digester every 1½ hours (90 min) on average.
- Section II pumps mix and transfer digested separated liquid manure from storage to slurry tanks for land application or directly into irrigation lines
- Section III mix and transfer materials for co-digestion with manure to the digester

Digester

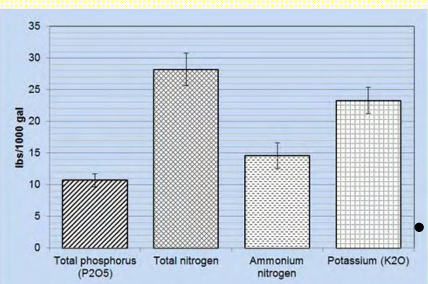
- The digester combines attributes of mixed completely mixed and plug flow type digesters.
- Overall dimensions: 158 ft long, 75 ft wide, 16 ft deep.
- Has two chambers. The first is an acid chamber where most of manure fermentation occur to provide acids needed to produce biogas. The acid chamber is about 20% of the total volume of the digester.
- The top 24 inches of the digester contains biogas.
- Receives about 25,000 gallons of manure daily. Approximately 1,600 gallons are pumped from the reception pit into the digester every 90 minutes.
- Every time manure is fed to the digester, an equal volume is displaced at the digester outlet.
- Manure retention time in the digester is about 28 days.
- The digester is maintained at a temperature of 101°F using heat from the engine or boiler.



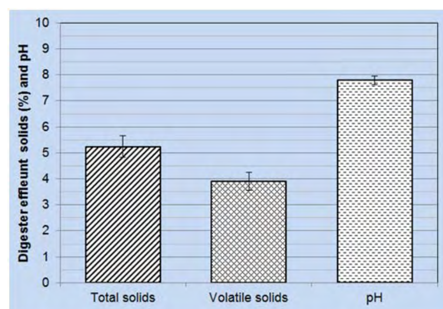
- On average 200,000 cu ft of biogas produced per day
- Quality of gas produced: 56% methane, 40% CO_2 and the rest is other gases.



- Biogas runs the engine, boiler or flare



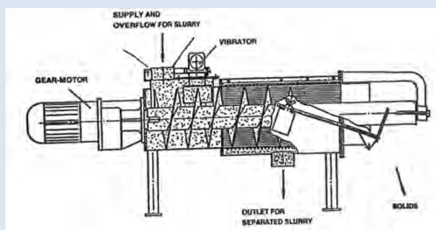
- The major nutrients N, P, and K maintain consistent values following digestion. The ratio of total nitrogen to total phosphorus on a mass basis is about 2.7, similar to the raw manure N:P ratio. There is no change in total N and P concentrations between raw and digested manure.
- Ammonium-N accounts for 51% of the total nitrogen in digested manure. Reactive P accounts for 6% of total P in digested manure.



- pH and solids content in digested manure have little variability.
- Digestion reduces volatile solids by about 35%. Total solids are reduced by about 30%.

Solids Separator

- Receives and separates digester effluent (digestate) into solids and liquids
- The separators are mechanical and use screw press technology to dewater digestate.
- The separator has a screw auger and cylindrical wire screen with 0.5 mm slot openings. Solids are retained on the screen and moved towards the separator outlet by a screw auger. Solids build up at the separator outlet provide a squeezer surface. Weights on the sides of the separator are used to increase resistance to the movement of solids to take more water out to provide dryer material.



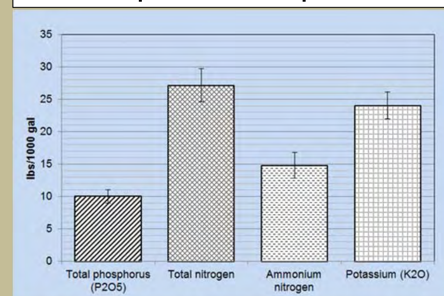
The inside of the wire screen

Outside surface of the wire screen

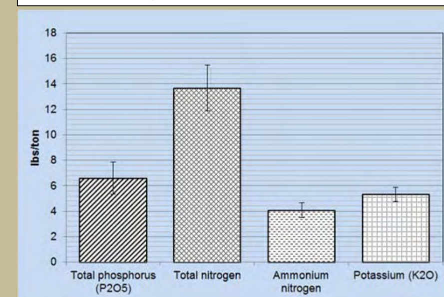
Tank for holding separated liquid before being moved to long term storage

Storage for separated solids

Separated Liquids



Separated Solids



- The separated solids have 25-30% dry matter and are used as animal bedding. The solids can also be used as fertilizer because of the residual nutrients content.
- For every 1000 gal (approx. 8,300 lbs.) of digestate processed,
  - 760 lbs. (wet basis) of solids are produced.
  - Separated solids contain18, 23, and 9% of N, P, and K in the digestate, respectively. The remaining 88, 77, and 91% of N, P, and K, respectively, are in the separated liquid.
- The separated liquid is used as liquid fertilizer.

Biogas Utilization: Electricity Generation

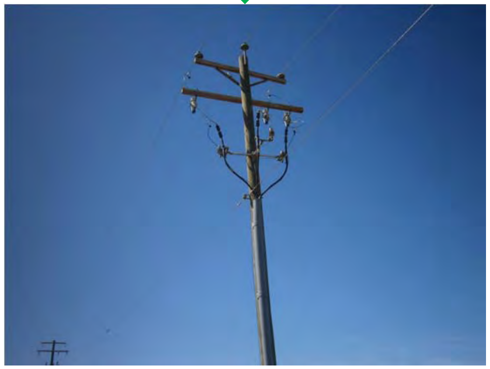
- The biogas produced is used in an internal combustion engine which in turns runs a generator to produce electricity.
- The generator – engine (Genset) is a 450 KW Guascor Generator Model No. MGG-712 supplied by Martin Machinery
- The generator efficiency is 35%. This means that the only 35% of energy in the biogas will be converted into electricity Some of the energy is recovered and used to heat up the digester to maintain the temperature at 101°F
- On average, 360 KWH of electricity is produced
- Biogas needs to be cleaned of hydrogen sulfide gas which currently runs at less than 200 ppm

Electricity Use and Production

- The electric energy consumed by the digester system components, e.g. pumps, is less than 10% of the electricity generated

Service and Maintenance

- Engine oil is changed approximately after every 550 hours of engine (about every 23 days)
- Takes about 45 min to change oil
- Routine daily check on the digester system: 20 minutes



Boiler

- Used when engine is not running
- Type: Columbia boiler, model MPH 60
- Gas input: 2,520,000 Btu per hour
- Efficiency – 83%
- Water capacity (flooded): 321 gallons
- Water Capacity (steam): 238 gallons
- Steam output: 2,070 lbs per hour

Flare

- The flare burns any gas not used by the generator or boiler. Flaring prevents the escape of unburned biogas into the atmosphere, providing an environmentally sound way to destroy methane to reduce the greenhouse effect.
- The flare turns on automatically in the event of a shutdown of the engine or boiler.

Contact:

Jactone Arogo Ogejo, Ph.D., P.E

Associate Professor and Extension Specialist
Biological Systems Engineering
Virginia Tech
Blacksburg, VA 24061
Tel: (540) 231 6815
Email: arogo@vt.edu

Martha A. Walker, Ph.D.

Community Viability Specialist
Virginia Cooperative Extension
150B Slayton Ave., Suite 112 D
Tel: (434) 766 6761; cell (434) 709 1084
Email: walker53@vt.edu